PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON THE LITTLE ICE AGE CLIMATE

GLOBAL-SCALE TEMPERATURE CHANGES DURING THE PERIOD OF INSTRUMENTAL RECORDS

P.D. Jones[1] and R.S. Bradley[2]
[1]Climatic Research Unit, University of East Anglia, Norwich, U.K.
[2]Department of Geology and Geography, University of Massachusetts, Amherst, Massachusetts, U.S.A.

ABSTRACT

The history of hemispheric- and global-scale temperature change since the 1850s is discussed. The long-term warming in the Northern Hemisphere is shown to be seasonally specific with temperatures in summer now no different from those in the 1860s and 1870s. The patterns of seasonal temperature anomalies during the 1980s, the warmest decade, are shown. Prospects for extending the record back before 1850 using instrumental data from Europe and North America are addressed.

1. INTRODUCTION

Although the thermometer was invented in Europe in the seventeenth century, it is only since the middle of the nineteenth century that there has been a reasonable network of temperature measurements from the land and marine regions of the Earth's surface. Coverage during the late nineteenth and early twentieth century can, however, never be described as good with many interior parts of Africa, South America, Australia and Asia missing. Ocean data is poor in the Pacific Ocean until the 1930s and in-situ measurements of marine temperatures are not available for the southern oceans south of 40°S even now.

2. THE RECORD SINCE 1850

Despite the above limitations, hemispheric and global temperature time series have been derived for the last 140 years. Figures 1 and 2 show such series on a seasonal and annual basis. For complete details about the construction and reliability of these series the reader is referred elsewhere (Jones *et al.*, 1986a,b; Folland *et al.*, 1990; Jones and Wigley, 1990 and Jones *et al.*, 1991). Both hemispheric annual series show warming since the 1850s of the order of 0.5°C. The warming is roughly linear in the Southern Hemisphere but somewhat erratic in the Northern Hemisphere. In this hemisphere, most of the long-term warming has taken place between the mid 1910s and 1940, although recent warming has made the 1980s the warmest decade in both hemispheres (Table 1).

The warming evident in the annual curves is one of the main pieces of evidence in the 'global warming' hypothesis. The use of such a term, however, does not do justice to the information that can be gained from the data. The warming is not in every season and it could never be classed as global in scale. The seasonal curves in Figures 1 and 2 show that the course of temperature change varies considerably during the year. Of particular note, is the lack of long-term warming in the summer in the Northern Hemisphere. Temperatures during summer are now no warmer than they were during the mid-nineteenth century. Warming in the Northern Hemisphere is slightly greater during spring as opposed to winter and autumn.

One means of illustrating that the recent warmth is not global in extent is to consider the spatial pattern of warmth during the 1980s (Figure 3). The warmth of the decade is most evident during the winter and spring seasons in the Northern Hemisphere. However, both ocean

areas of the hemisphere exhibit colder than normal (1950-79) temperatures. The Greenland-Iceland-North Atlantic region has been cooling since the 1940s (Jones *et al.*, 1991). Although most of the Southern Hemisphere experienced warmer than normal conditions, significant areas of Antarctica and South America were colder.

3. INFERRING CHANGES PRIOR TO 1850

In the previous section, it has been shown that in order to obtain the global picture of past changes, data is required from all regions of the Earth's surface. Warming trends this century were uneven both spatially and during the four seasons. Thus we should not expect to be able to extend our time series backwards without some reduction in the quality and reliability of the record. In this section, we consider what the limited temperature recording network prior to 1850 can tell us about earlier times.

In Table 2, we give correlation coefficients between 13 regional time series and the hemispheric averages over the period 1901-90. The choice of the regions is somewhat arbitrary and not meant to be exhaustive. Some represent regions where long palaeoclimatic reconstructions have been made, while others represent relatively large coherent areas. The purpose of the analysis is to see if some regions of the world appear more important than others. Extreme caution must be exercised in interpreting the results as the relationships found may only be relevant to the twentieth century. The corollary of this is that regions which appear less important now may have been more important during earlier centuries. Intuitively, however, it would seem difficult to place great faith on long time series from regions which show little agreement with hemispheric-scale averages during the twentieth century.

The results in Table 2 show that the regions with the highest correlations are the tropical oceans. The lowest correlations from the selected regions tend to be found over Eurasia, precisely in the areas with the longest instrumental records. For example, the long Central England temperature series of Manley (1974) might have been more useful, based on twentieth century data, if it had been located in northwestern North America, southwestern Europe or southern Africa.

The above analysis shows that inferring temperature trends prior to the 1850s from instrumental data will be problematical as the station coverage is limited to only land-based data from Eurasia and eastern North America. Jones and Bradley (1992) have studied several long station records from these regions. The common features of the records suggest that these regions of the Northern Hemisphere were cool during the 1780s, 1810s and the late 1830s, with warmth dominating the 1820s. The cold-warm-cold oscillatory pattern between the 1810s and 1830s is evident in most records for the two regions covering this period.

4. CONCLUSIONS

The world has warmed 0.5°C since the middle of the nineteenth century. All of the warming in the Northern Hemisphere has occurred in winter, spring and autumn. Summers now are no warmer than in the 1860s and 1870s. Over the Southern Hemisphere, warming has occurred in all seasons. The 1980s was the warmest decade yet recorded, despite large areas which were colder than the 1950-79 average.

Table 1. Decade-average temperatures (land-plus-marine) with respect to 1950-79.

	NH	SH	GL
1861-70	-0.26	-0.36	-0.31
1871-80	-0.27	-0.36	-0.32
1881-90	-0.35	-0.31	-0.33
1891-1900	-0.27	-0.25	-0.26
1901-10	-0.33	-0.37	-0.35
1911-20	-0.34	-0.24	-0.29
1921-30	-0.16	-0.26	-0.21
1931-40	-0.04	-0.12	-0.08
1941-50	0.04	-0.04	0.00
1951-60	0.05	-0.05	0.00
1961-70	0.02	0.00	0.01
1971-80	-0.05	0.06	0.00
1981-90	0.20	0.26	0.23

Table 2. Regional series correlations with the appropriate hemispheric average series (1901-90, Annual)

Region (Name)	Area	Correlation with NH	Correlation with SH
Tropical Indian Ocean	10°N-10°S, 50-100°E	0.69	0.81
Tropical Atlantic Ocean	10°N-10°S, 0-50°W	0.74	0.75
NW North America	40-60°N, 110-130°W	0.65	
Iceland	60-70°N, 10-30°W	0.30	
Fennoscandia	60-70°N, 10-40°E	0.26	
England	50-60°N, 10°W-5°E	0.39	
Siberia	45-65°N, 70-120°E	0.51	
SW Europe/NW Africa	25-40°N, 0-20°W	0.78	
SW U.S.A.	30-40°N, 105-125°E	0.52	
Southern Africa	20-35°S, 20-35°E		0.82
E. Eq. Pacific	5°N-10°S, 80-120°W	0.31	0.45
Central South America	20-40°S, 50-75°W		0.67
Western Australia	20-35°S, 110-130°E		0.68

The possibility of extending the time series back beyond 1850 using the longer instrumental records from Europe, Asia and North America was addressed. Extreme care should be taken about inferring trends for larger-scale regions.

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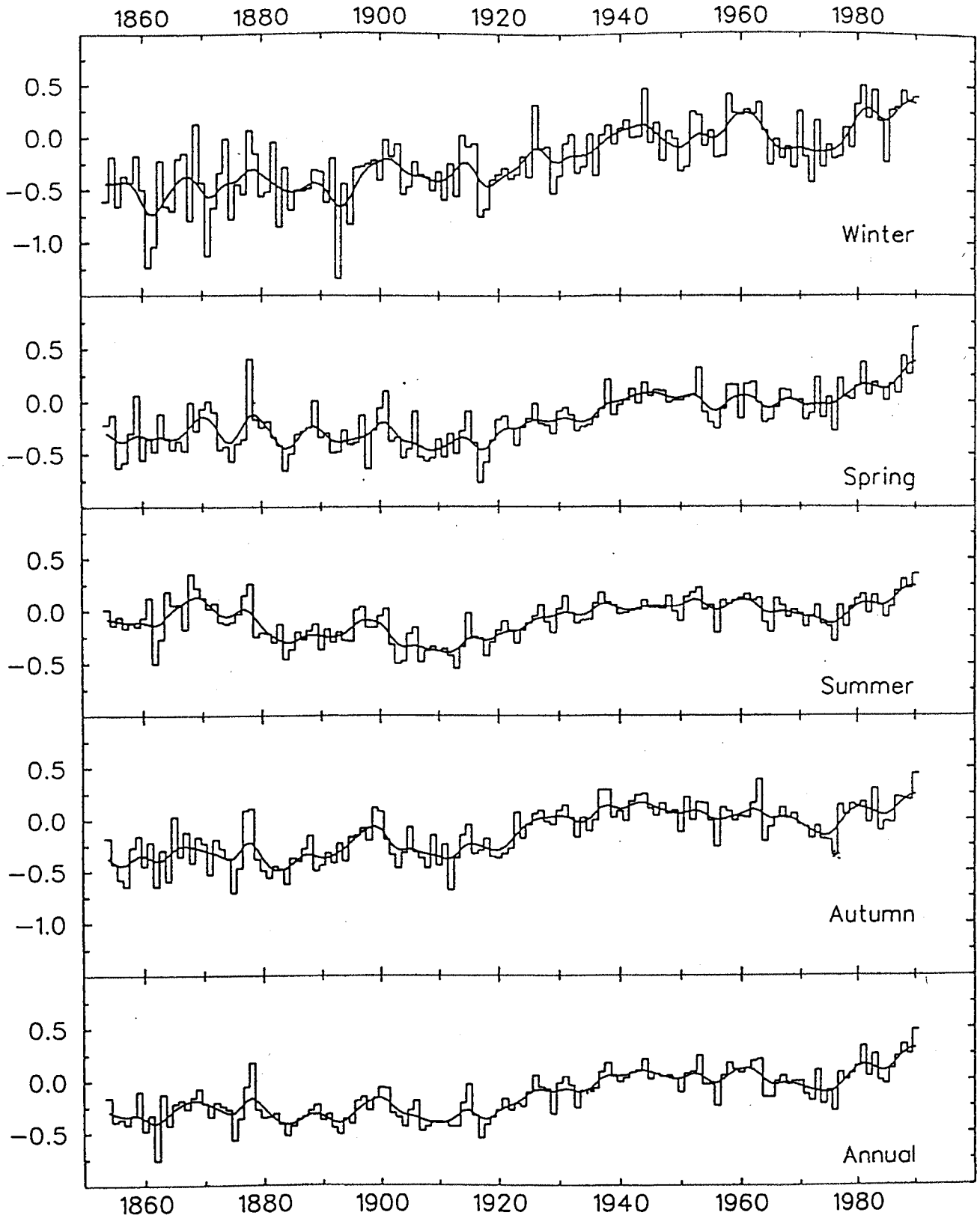

FIGURE 1. Northern Hemisphere surface air temperatures (land plus marine data) by season, 1854-1990. Data are expressed as anomalies from 1950-1979. The smooth curves were obtained using a 10-year Gaussian filter.

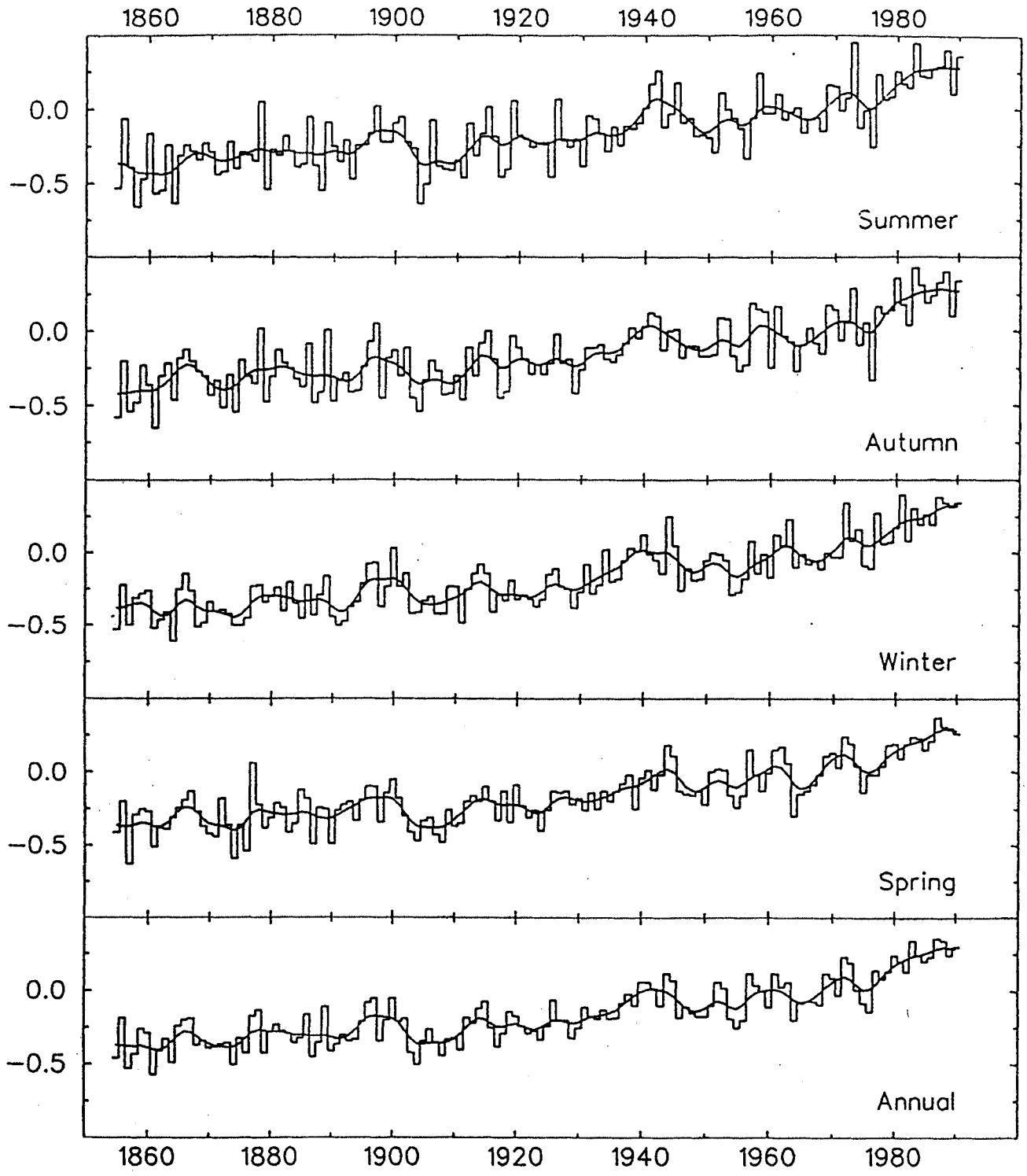

FIGURE 2. Southern Hemisphere surface air temperatures (land plus marine data) by season, 1854-1990. Data are expressed as anomalies from 1950-1979. The smooth curves were obtained using a 10-year Gaussian filter.

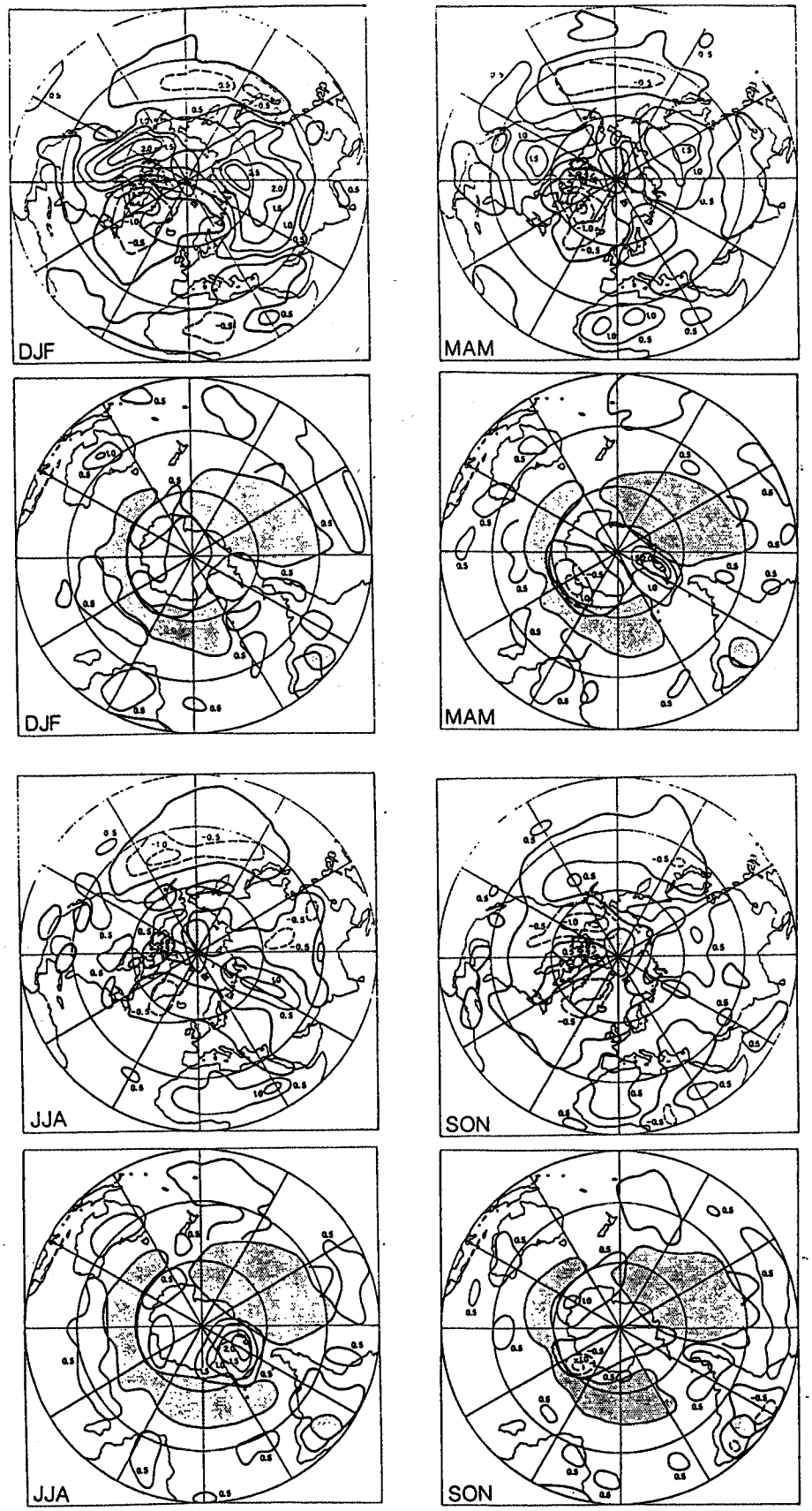

FIGURE 3. Seasonal temperature anomalies for the Northern and Southern Hemispheres for 1981-1990. Anomalies are based on the 1950-1979 period and the contour interval is 0.5°C with negative anomalies dashed. Shaded areas indicate regions with insufficient data.